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ABSTRACT

The general nature of collaborative work among peers in classrooms is discussed. This framework is applied to the interpretation of a 2-year study which examined how pairs of children in two classrooms (8- and 9-year-olds; 11- and 12-year-olds) worked together to solve computer programming problems in the LOGO language. It was found that students collaborated more when they worked on microcomputer problems than on other classroom tasks, e.g., math and language arts, probably because of specific features of the technology, the expertise available, and the status of the work. There was, however, a wide variation among pairs in the interactions that occurred. For some pairs there was very little planning or evaluation throughout the task, while other pairs engaged in a great deal of planning. When planning occurred, students almost always engaged in some form of negotiation. More evaluative discussion of work occurred in later problem solving sessions. Students were not greatly involved in or successful at explaining a course of action before proceeding with it. There was consistency in the types of interactions that occurred at the beginning and after a year's experience with LOGO, with the possible exception of an increase in evaluative discussion. (Author/MBR)

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Paired Problem Solving in a Computer Context

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and Peggy Heide

Technical Report No. 33

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Abstract

Collaborative work arrangements are common features of people's lives. In this paper, the general nature of collaborative work in classrooms is discussed. This framework is applied to the interpretation of a study which examined how pairs of children worked together to solve computer programming problems in the Logo language. The children's collaborative work when they were first learning Logo was compared with their work on a similar though more difficult set of problems after a year's experience with Logo.

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PAIRED PROBLEM SOLVING IN A COMPUTER CONTEXT*,**

Jan Hawkins, Moni Homolsky,
and Peggy Heide

Collaboration is a common feature of our work lives. Some collaborative arrangements are specifically geared to getting complex jobs done efficiently (e.g., a group of Swedish auto workers collaborating on the production of a single automobile). More frequently, however, collaborative arrangements are not well defined. People often collaborate informally in their work, because they want to or because they need help from others. So, for example, we might collaborate with a friend in getting a cake baked, or with a colleague in writing a paper because we both have a stake in the work. The procedures for doing the work are defined and modified as we go along. Collaboration can be organized in many ways: people can work jointly on a task to achieve a common goal; or they can apportion parts of a complex task to individuals that are later assembled to form a finished piece. The nature of the collaboration that occurs is best described as local. It is related to the work environment, the type of tasks, and the skills and values of the individuals involved.

Schools present an interesting case. Collaboration over work has a paradoxical status in many classrooms. The ostensible work of schools is learning, which is generally viewed as an individual affair. Interviews that we have conducted with students (beginning with third graders) indicate that by the time they reach this grade level, children have acquired a sophisticated understanding of the social organization of work in their classrooms. They have a good idea about what forms of interaction are appropriate for what occasions. Help can be sought in certain explicitly or tacitly agreed-upon ways

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and circumstances, but accountability for what is done or known is almost always based on the performances and products of individuals. There are some classroom tasks, however, where collaboration seems to be the norm: painting a mural or putting on a play are commonly organized as collaborative projects by groups of children. But these tasks are generally perceived by teachers and students as peripheral to the core learning that is expected to be accomplished in classrooms. In contrast, it is not generally acceptable to collaborate on the answers to a math test, or even on a math worksheet or homework.

Collaboration often has an ambiguous status for both teachers and children in classrooms. It is part of the educational rhetoric: in the earlier grades children are asked to share materials and space; in middle school they are often told to work together; in college students work on group projects and are frequently uneasy about the resulting group grades. On the other hand, both teachers and children are aware of the heavy emphasis on individuality in the central learning tasks and accountability systems of classrooms. Schools are places where people learn about the social organization of work--what the acceptable forms are, and the skills needed to accomplish school tasks.

There is evidence that collaborative work among peers has great value: much can be learned from reformulating information, engaging in discussion and argument about a problem with people of different skill levels, and watching what peers do. But we cannot ignore the counterargument that it can impede individual acquistion of knowledge and skills because at least some students will come to rely on others to get their work done. This is probably complexly related to the emphasis on isolated individual knowledge and fear of failure. Facility with both kinds of learning is desirable, and one can imagine an environment in which learners freely and appropriately engage in both. Aside from highly structured programs for organizing collaborative environments in classrooms, collaboration remains an ambiguous part of the classroom context. While nominally valued, it commonly is not a well-integrated nor fully <u>trusted</u> learning form in many classrooms.

How do microcomputers fit into a discussion of collaborative work? An early finding--something noticed as soon as computers were introduced into classrooms--was that children were working together more. This phenomenon, noted by both teachers and researchers, was often presented as a benefit of the presence of microcomputers. Microcomputers were part of a learning environment that seemed to support children's seeking help from one another and exchanging information. No one was quite sure what the children were doing or why comput-

ers should support this form of learning, but there was clear evidence of increased collaboration.

At the Center for Children and Technology, we conducted a two-year program of research about the effects of using the programming language Logo in classrooms. We were interested in both cognitive and social issues: What and how were children learning and was this learning transferable as general problem-solving skills? How were the hardware and software interpreted by teachers and incorporated into the organization of classrooms? We were particularly interested in examining the issue of collaboration among peers in microcomputer tasks.

Our interest in the organization of such work, and the notion that computers might be a central and valuable form of learning that would contribute to the salience of collaboration in classrooms, led us to pursue the problem. Were the microcomputers and the problem-solving environment offered by Logo facilitating effective collaborative work among children? Our central questions were: Was joint work occurring? What were children doing when they worked together? What skills were they learning? Was the social organization of work in the classroom modified? How did the situation change over the course of the two-year research period?

Thus, our program of research with Logo was designed to answer a series of related questions about both cognitive and social issues. We decided to work intensively in two classrooms (8- and 9-year-olds; 11- and 12-year-olds) in order to get an in-depth understanding of the course of development. We worked with the same two teachers throughout the project, and two cycles of 50 children. While recognizing this to be a gloss, we can generally describe the teachers as advocating a child-centered approach to learning, with their classrooms organized accordingly. Much of the work was done in small groups, and children were given frequent opportunities to work on their own or together. The pedagogy associated with Logo was therefore compatible with their overall framework.

Each classroom was equipped with six microcomputers and Logo software. The programming work became part of the classroom agenda, although the teachers' thinking about how to incorporate the work changed considerably, and was still not settled by the end of the project. With respect to evidence of peer collaboration, we did regular, systematic observations in classrooms to determine whether, where, and how much collaborative work occurred; we interviewed teachers and children about their understanding of the social organization of the work in their classrooms; we collected ethnographic

material about the computer work as it unfolded; and we videotaped children as they worked together to solve problems.

Before discussing the videotaping study in more detail, we will present a brief overview of our findings. From the systematic, time-sampled observations of classrooms, we found that kids did collaborate more when they were working on microcomputer problems than they did on other classroom tasks (e.g., math and language arts). This was consistent over time for both classrooms and for the two project years. But, as the year progressed, we found a greater occurrence of individuals working alone at the computers in a very focused way. These findings have been reported in some detail elsewhere, but the study didn't tell us what the students thought about this form of work or what, in fact, they were doing as they worked together.

Interviews with students revealed that their interpretation of collaborative work is both local and ambiguous. They spoke about its value in terms of specific tasks; for example, collaboration with peers is helpful for social studies and when you run into a problem, but not so good when doing math, research, or homework. Many students clearly had reservations about the legitimacy and value of collaboration in a number of learning situations: "You can work faster by yourself"; "You don't have to share your ideas; "There's no interference from someone else"; "Kids need to do their own work." Most children said, in one way or another, that if you wanted to do something efficiently, you did it by yourself. Most children also had the idea that in the realm of "real school work" (i.e., core curriculum), collaboration was sometimes equivalent to cheating.

While valuing collaborative work, the teachers had some difficulty with organizing it and encouraging it in their classrooms. Interviews with the teachers revealed that they struggled with the problem of how to teach Logo, and how much they could reasonably require of the children in learning the programming language. The issue of Logo as legitimate work was debated over the course of the two years, and was a source of discomfort to both teachers and children. Just what was this work and who was responsible for getting it done? Could all legitimate work be in the form of collaborative projects, or was some individual responsibility for programming concepts and procedures necessary?

How then do computers and Logo fit into the collaborative environment? When interpreted in light of the development of the overall environment, we found several likely explanations for the greater collaboration with the computers:

- Features of the technology, most notably the screen which makes work very public: Children could easily see, and become involved in what others were doing.

- Features of the expertise available: Computers and Logo were new to these classrooms and teachers, as they are to the large majority of schools. At the beginning of the work, the teachers did not feel themselves to be in control of the subject area, and thus were not confident experts. Consequently, given the open organization of the computer work, the teachers encouraged and welcomed the children's helping one another. The familiar classroom organization consisting of one adult expert to many novices was, in effect, reversed. Since there was no expert resource, part of the work involved increasing the teacher's knowledge as well as the emergence of a pool of expert students. These teachers welcomed this development.

- Features of the status of the work: Nobody was quite sure that computers were legitimate work, nor did they know how to set up an accountability system. Because it was so different from the core curriculum of the classroom, programming work was defined as a new category of activity, rather than being assimilated into other subject areas such as math. Since nobody (neither the teachers nor the children) was sure what should be known about programming or just what its value was, there were multiple interpretations of what was going on. Nobody could say what facts, concepts, and skills had to be acquired. As a result of the work's being oriented around the development and execution of programming projects, group projects were just as acceptable as individual projects. The nonlegitimacy of the computer in relation to other classroom work meant that the usual constraints on the appropriateness of collaboration did not apply. The social organization of this work could develop quasi-independently of the other subject areas. Some people liked this, while others were very uncomfortable with it.

Finally, given that students were collaborating on programming work, just what were they doing when they did it? Here, we will briefly describe a series of studies in which we asked pairs of children to work together to solve problems, and videotaped them as they did so. Twelve pairs of children were selected to participate in these sessions over the course of a school year: six pairs of older and six pairs of younger children; six pairs each of boys and girls. Each pair participated in four problem-solving sessions at different points during the year: two sessions with the computer solving Logo problems; one session planning, without the computer, how to construct a program; and one session solving a math work problem, because we wanted to compare the computer collaborative work with a more traditional

classroom task. The sessions were videotaped, transcribed, and analyzed according to the way the students organized the task, and the interactive work they engaged in to accomplish what they did. Since we accumulated a vast array of data, this discussion will be limited to summary remarks about the two Logo problems.

In order to understand how the children used the programming concepts available to them, we constructed a series of related problems for them to work on in each session. Doing Logo well involves a knowledge of both programming and geometry. Because we wanted to minimize the intrusion of misunderstandings concerning geometry (particularly the lengthy negotiations that can take place about how to construct an angle), all of our problems involved procedures to construct boxes. The children worked together on one set of problems early in the school year, and on a related set at the end of the year. In each session, the children were given three related problems to solve. We wanted to see how they would use their previous accomplishments to help in the solution of a subsequent problem. The children were asked to solve the problems in the best way they knew how. Several things should be noted here about this collaborative situation: (1) the experimental session explicitly required collaboration among the children; (2) the situation required simultaneous joint work, rather than division of work into discrete units for individual solution; (3) the context was different from that of the normal classroom; (4) although the pairs were chosen on the basis of their compatability, the interrelationships obviously varied from pair to pair; and (5) levels of knowledge about and interest in programming, geometry, and collaborative work varied. The effects of all of these features, and more, are likely to be important in understanding a collaborative event. In our work, only a few of these features are at least partially known for the pairs, and some can't be helped.

Within these constraints, what characterized the collaborative work among the children in these sessions? Each transcript was divided into "chunks"--child-defined units for getting the task done. Each chunk represented a work sequence subsumed under a singular topic or focus, such as drawing a line, or figuring out how to construct an angle. These chunks were then coded for certain task configuration and interactive properties. The work of any one chunk could be examined in terms of the planning, action, and evaluation of the collaborative outcomes, and the interactive work that led to those outcomes. Most pairs never arrived at a full solution to the three related problems in the allotted time, but their work sequences were analyzed according to the proportion of chunks containing particular types of interactions. We will briefly summarize the overall characteristics of these interactions across all pairs.

The first finding of note is the wide variation among pairs in the interactions that occurred. For some pairs, there was very little planning or evaluation throughout the task. Rather than discussing what they were doing, these children just did it, with child-to-child prompts or directions constituting the main form of work-related interactions. Other pairs engaged in a great deal of planning before they did the work; for some, more than half of the chunks contained interactions surrounding the planning of what was to be accomplished.

There appeared to be more evaluative discussion of work in the second problem-solving session than in the first. That is, some pairs appeared to engage in more interaction about the results of an action --a process that allowed them to make revisions--than they did initially. This may be related to the children's increasing knowledge of Logo, and their ability to think about correcting errors rather than throwing the whole thing out and beginning again. The "throw it all away" strategy, rather than debugging a faulty procedure, characterized the efforts of many young novices with Logo.

When planning occurred in a work unit, the children almost always engaged in some form of negotiation about what was to be done. For some pairs, this was frequently collaborative (in up to half of the work units), and each member contributed to an egalitarian discussion or argument. For some pairs, however, the negotiation was often asymmetric (in up to 60% of the work units), where one member dominated the exchange and made the decisions. And some pairs never reached explicit agreement. In this model of work, one member tacitly acquiesced to the other's opinion without necessarily ever seeing the point. These singular styles were dominant for several pairs, whereas other pairs engaged in a combination of collaborative, asymmetric, and independent decision making.

Generally, in most pairs the children made little attempt to explain, show, or convince one another of what was meant or to take a proposed course of action. Only about a third of the negotiations were accompanied by verbal explanations, and the same was true for nonverbal demonstrations. In other words, the children were not terribly involved in or successful at explaining a course of action before proceeding to accomplish it.

When actually typing in or running the programs, the children did a lot of talking, a great deal of which was task related. In many of the pairs, one child prompted the other by giving him or her directions about what to do. In other cases, the child performing the action talked aloud, either to orient his partner or himself. Children also talked about other things as they worked, and sometimes fooled

around, but this was largely peripheral to the ongoing work. There were very few action-chunks that contained no discussion at all.

With the possible exception of the increase in evaluative discussion, there seemed to be considerable consistency in the type of work-related interactions that occurred at the beginning of the year and those that occurred after a year's experience with Logo. That is, overall, the children did not appear to engage in more or more successful negotiations, or more explicit presentation of explanations or information to each other after a year's experience with Logo.

In summary, the children were clearly engaged deeply in the work and evidenced different collaborative patterns. We believe that these different patterns were in part related to level of expertise (age being merely one factor), as well as interest in and ability to collaborate with someone else. The computer provided an engaging problem-solving context in which task-related talk occurred. An examination of the interactions for the remaining two problem types (math and program planning) may reveal how differences in task environment relate to collaborative work.